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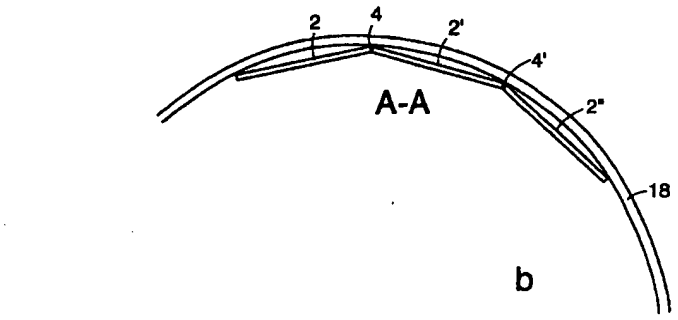
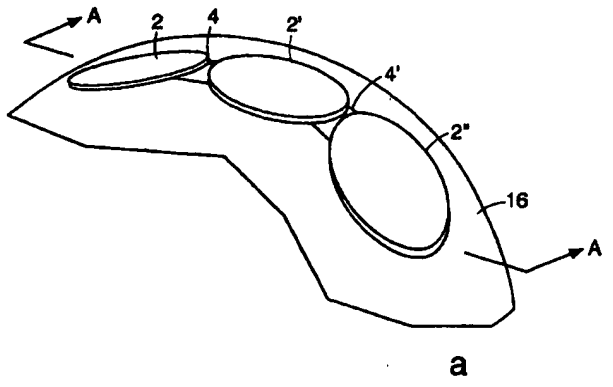
(54) Title: MOLDABLE TRANSCEIVER FOR USE WITH APPAREL

(57) Abstract

A transceiver for use with apparel is described which uses flexibly interconnected electrical components that are substantially deformable so as to conform to the shape of the apparel. The transceiver comprises a transmitter and receiver which are electrically coupled to a power supply and an antenna. Another embodiment the invention includes apparel which comprises a transceiver that is substantially deformable to conform to the shape of the apparel and a support member for attaching the transceiver to the apparel.





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MOLDABLE TRANSCEIVER FOR USE WITH APPAREL

Field of the Invention

The invention relates generally to moldable electronics for use with apparel. In particular, this invention relates to electronics for radio communication, multilateration, telemetry, patient monitoring and recordation that conforms to the user's body.

Background of the Invention

Pilots, athletes, military personnel, motorcyclists, bicyclists, firemen, policemen, healthcare workers, medical patients, miners, etc. all use radio devices that are conveniently located in apparel such as in a pocket, purse, or on a belt. Another possible location for radio electronics is to integrate the electronics into the apparel. Radio electronics have been integrated in clothing, wristwatches, and helmets, for example.

Integrating electronics into the apparel of a user has many disadvantages, such as causing the apparel to be too heavy or too bulky and uncomfortable for the user to wear. In addition, in many cases these electronics are not designed to withstand the abuse that the apparel is subjected to in extreme conditions, such as in sporting events and will likely fail under such circumstances. Also, these electronics are typically designed for multiple applications and not generally designed for a specific piece of apparel.

These problems are exaggerated in specialized apparel such as in helmets. Helmets are primarily designed to absorb forces in the outer shell and compressible pads, and by distributing the impact over a large surface area. An absence of protrusions in the helmet is necessary to prevent injury to others and to avoid force concentrations during impacts. The spherical shape of

the helmet is necessary to internally distribute forces over the largely spherical skull and externally to prevent force concentrations during impacts. Other, secondary design objectives of the helmet are that it should be light weight, have good comfort and fit, good balance, be chemical and perspiration resistant, and be aesthetically pleasing. Many transceivers that are embedded into helmets of today are not small enough to embed without modifying the helmet. They are also relatively heavy and too thick to mount in the helmet without substantially affecting the fit and balance of the helmet. Helmets that are unbalanced or do not fit correctly can be uncomfortable for the user to wear.

Prior art helmets mount radios on the outside of a helmet or in a pocket inside the helmet. These helmets also have their control electronics such as knobs, connectors, wires, and antennas directly mounted to the surface of the helmet. These modifications are disadvantageous and can lead to injuries if the helmet's impact absorbing characteristics have been changed from its original design to accept the electronics.

Other apparel transceivers have been mounted on sneakers, belts, and wristbands or watches for example. Prior art approaches have many disadvantages. For example, clipping the transceiver to a belt can cause injury if the user falls and lands on it. The fall may also destroy the transceiver. In contact sports, the players could be injured by a protruding transceiver. Also, the belt clip may loosen causing the transceiver to drop and possibly be damaged. Wrist mounted transceivers have the disadvantage of being bulky and heavy and can be uncomfortable to wear. Shoe or sneaker mounted transceivers are typically attached to the shoelaces and can be uncomfortable while walking or running.

Another prior art transceiver is mounted to the user's chest with a belt or adhesive tape.

This arrangement allows for the taking of a user's pulse while she is running on a treadmill, for example. This approach also has disadvantages including an uncomfortable fit, restrictive breathing and the possibility of serious injury, if the user falls forward.

Summary of the Invention

It is therefore a principal object of the invention to provide a transceiver or other electronics such as sensors that are moldable to the apparel or the body of a user by using flexibly interconnected electrical components. It is another principal object of the invention to provide a flexible antenna that directs electromagnetic radiation away from the user. It is yet another principal object of the invention to provide a helmet that incorporates the transceiver of the present invention without modification to the comfort or protective properties of the helmet. It is still another principal object of the invention to provide a wireless charging system for recharging the battery of the transceiver in a helmet.

Accordingly, the present invention features a transceiver that includes a power supply, an antenna, and flexibly interconnected electrical components which are substantially deformable so as to conform to the shape of the apparel. In one embodiment, the antenna is flexible. In one embodiment the antenna is directional so as to direct electromagnetic radiation away from the user. The transceiver's power supply may be a battery. The transceiver may be connected to one or more sensors.

The present invention also features apparel including a transceiver that includes flexibly interconnected electrical components that are substantially deformable so as to conform to the shape of the apparel. The apparel also includes a support member for attaching the transceiver to the apparel. For example, Velcro® or double-sided tape may be used to support the transceiver.

The present invention also features a helmet that includes a transceiver comprising flexibly interconnected electrical components which are substantially deformable so as to conform to the shape of the helmet. The transceiver also includes an antenna. The transceiver can be disposed between a protective member and an outer surface of the helmet. The transceiver's power supply may be a rechargeable battery.

The present invention also features a method of recharging a battery in a helmet by supplying a charging current into a first coil of a recharging system and positioning the helmet which comprises a second coil in electromagnetic communication to the first coil, wherein a charging current is induced from the first coil to the second coil, thereby charging the battery in the helmet.

Brief Description of the Drawings

This invention is described with particularity in the appended claims. The above and further advantages of this invention may be better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1(a,b) illustrates an embodiment of moldable electronics according to the present invention.

Fig. 2(a,b) illustrates an embodiment of moldable electronics according to the present invention showing a spherically conforming arrangement of interconnected tiles.

Fig. 3 is an illustration of another embodiment of the invention showing a nearly spherical arrangement of interconnected tiles.

Fig. 4 is an illustration of yet another embodiment of the invention showing another

arrangement of tiles.

Fig. 5 is an illustration of an embodiment of the invention showing a sealable protective enclosure.

Fig. 6 is a block diagram of an electrical circuit which could be used in conjunction with the invention.

Fig. 7 is an illustration of an embodiment of the invention showing a helmet with an inductive battery charging device.

Fig. 8 is a cross-sectional view of the embodiment of the inductive battery charger of Fig. 7.

Detailed Description

Fig. 1a illustrates transceiver of the present invention comprising electronic components or tiles (2, 2', 2'', 2''') flexibly interconnected by flexible interconnects (4, 4', 4'', 4'''). The tiles (2, 2', 2'', 2''') are also in electrical communication with a power supply 6. The power supply 6 may be a battery or any other power source. The battery could be disposable or rechargeable. For example, the power supply may be capacitors, alternating current power supplies, direct current power supplies, and generators. Examples of generators that may be used with the present invention include a kinetic generator, which stores energy derived from the user's motion or a typical "bicycle-type" generator, which stores energy derived from the motion of the equipment the user is utilizing.

It should be noted that although the embodiment shown in Fig. 1a illustrates circularly

shaped tiles (2, 2', 2'', 2'''), the tiles of the invention may be in any geometric shape which serves the purpose for which the invention was intended. These shapes include triangles, hexagons, trapezoids, and octagons to name a few. It should also be appreciated that the size of the tiles (2, 2', 2'', 2''') and the interconnects (4, 4', 4'', 4''') can vary depending on the application. In some cases the interconnects (4, 4', 4'', 4''') will be so small, that it will appear that the tiles (2, 2', 2'', 2''') are actually one flexible piece. In one embodiment, the tiles are shaped so their outline matches the outline of a slice taken from the surface they mount to, so as to provide support to the electrical circuitry on the tiles. In this embodiment, the shape of the mounting surface determines the shape of the tiles. In alternative embodiments, interconnects can be an integral part of the tiles, such as with flexible PC Boards. Alternatively, interconnects may be separate from the tiles, such as with cables.

The tiles (2, 2', 2'', 2''') in one embodiment are rigid to protect the onboard electrical component leads and connections against stress, but are flexible between each other to allow the transceiver to conform to the shape of the apparel. This can be accomplished by using a single tile 2 with flexible areas and rigid areas within it, or alternatively, by using rigid tiles (2, 2', 2'', 2''') connected by flexible interconnects (4, 4', 4'', 4''').

The length 12 and the width 10 of the transceiver shown in Fig. 1a may vary substantially. In one embodiment, the length 12 is approximately 267mm and the width 10 is approximately 51mm. Other embodiments include interconnecting the tiles at different points, creating customized patterns. These patterns could be shaped to conform to various application requirements. Fig. 4, for example, illustrates a triangular shaped pattern of tiles (2, 2', 2'', 2''') which concentrates the tiles around one location, whereas Fig. 1 illustrates a pattern that spreads

the tiles out in a line.

Fig. 1b illustrates that the thickness 14 of the tiles and the power supply 6 can also be varied depending on the application. In general, the components will be higher than the mounting surface. It is contemplated by the invention that surface mounted integrated circuits as well as other low-profile components could be used and these techniques are known in the art. In one embodiment, the thickness 14 is approximately 3.8mm.

In another embodiment, the invention includes a protective layer 8 to protect the transceiver from the surrounding environment. The protection could be from shock, perspiration, or other liquids for example. The protective layer 8 may also be an RF shield to protect the transceiver from electromagnetic radiation as an example. The protective layer 8 could also encase the transceiver completely. The transceiver may be hermetically sealed within the protective layer 8. The protective layer 8 may be comprised of plastic, fabric, metal foam, or any other suitable material. In one embodiment, the protective layer 8 is a "zip-lock" type plastic bag. It should be noted that the transceiver of the present invention is designed to withstand substantial impacts and other harsh treatment.

The transceiver of the present invention in another embodiment may be used without protective layer 8 when, for example, it is desired that the tiles (2, 2′, 2″, 2‴) rest directly on the user's body. This might be desired when sensing is required. For example, the tiles may be required to directly contact the skull for providing a magnetoencephalogram.

Fig. 2a illustrates tiles (2, 2′, 2″) that are connected by flexible interconnects (4, 4′). The tiles (2, 2′, 2″) are shown conforming to a spherical shape, and are interposed between an inner layer 16 of an apparel and an outer layer 18 of the apparel as shown in Fig. 2b. It is not

necessary that the apparel sandwich the transceiver, however, the transceiver must be secured to the apparel. The tiles may be mounted to a surface of the apparel using mounting procedures well known in the art, such as two-sided tape, or hook and loop mounts.

Fig. 2a illustrates the inner layer 16 of a helmet or a portion of a user's scalp for example. That inner layer 16 may be padded. Fig. 2b illustrates the outer layer 18 of a helmet. The outer layer 18 may be comprised of plastic, metal or some composite material. One purpose of a helmet is to protect the user's head by radiating an impact over a larger area of the head.

Fig. 3 is another embodiment of the invention showing tiles (20, 22, 24) configured in a non-spherical arrangement. Also shown is power supply 26, which could be a battery for example. This arrangement may be well suited to a piece of apparel not worn on the head, but perhaps an armband for instance.

It should be appreciated that since a transceiver of the present the invention is small, lightweight, and easily concealed it could be used for intelligence or law enforcement. For example, such a transceiver could be used to "wire" informants or others without risking "exposure" of the device to hostile parties. The device could be concealed in an area of the garment that is routinely overlooked in a typical "pat down" search such as on the shoulder. In one embodiment, the invention could be concealed in the hairpiece of a user, allowing an alternative mode of secrecy. In fact the invention could be used in any apparel including clothing, hats, bracelets, necklaces, shoes, sneakers, boots, socks, gloves eyewear, headphones, headbands, wristbands, helmets and numerous other types of apparel. In another embodiment, the apparel could simply be the support member that connects the transceiver to the user's body. That support member in one embodiment could be but is not limited to a rubber band, two-sided

tape, a wristband, a headband, a pocket in the apparel, or a bracelet, for example. In one embodiment, control of the transceiver, such as volume control, is accomplished through the use of a wireless radio control link. In another embodiment, control is accomplished through the use of an infrared (IR) link. A computer or electronic wristwatch could be used to control the transceiver for example. In yet another embodiment, an electronic link is provided to communicate with sensors or other electronic equipment worn by the user. In still another embodiment, the invention not only transmits and receives data, but also could be used to transmit or receive video, audio, and/or voice communication. The invention could also electronically record and store data.

Fig. 4 illustrates another embodiment of the invention showing multiple tiles 2 and interconnects 4 arranged in a triangular configuration. The number of tiles required for a giving application varies according to the functions desired. For example, the embodiment shown in Fig. 4 depicts six interconnected tiles. Each of these tiles contains circuitry. This circuitry may include transmitter or receiver circuitry, for example. Another tile may be a battery or contain battery recharging circuitry. The layout illustrated in Fig. 4 is an example of one typical configuration. Other configurations, for example, having ten tiles (not shown) may be required for other applications.

Each tile may have a different purpose and therefore contain different electronic circuitry. For example, one or more tiles may contain the battery charging circuitry, while other tiles may contain the receiver circuitry. Based on this, it should be appreciated that limitless applications could be created simply by choosing the appropriate tiles or by utilizing custom designed tiles.

Referring now to Fig. 5, battery 30 is shown. Battery 30 in one embodiment is a flat

battery. In an alternative embodiment, the battery 30 is deformable, and can be molded to suit the application. In yet another embodiment, the battery 30 may consist of multiple interconnected cells. The size and shape of the battery will vary depending on the requirements of the application. The battery 30 may be rechargeable or disposable.

The battery 30 is shown with tile 32 which includes a connector. A protective material in one embodiment could be used to protect the battery from shock. In one embodiment this material is shock absorbing foam. In an alternative embodiment, protective material could be plastic, cloth, metal, paper, fiberglass, or any suitable material. Protective material could be used to protect the user from a leaking battery 30 or alternatively, to protect the battery 30 from perspiration, spills, shocks, or RF noise, for example. In an alternative embodiment, protective material is not used. The protective material can be applied or removed selectively, to cover or expose necessary parts.

In one embodiment, battery 30 is enclosed in an encasement 34 that comprises a plastic "zip-lock" type bag for housing battery 30. Encasement 34 provides easy access to battery 30, while maintaining a protective covering to shield battery 30 from external forces. These forces might include shocks, perspiration, spills, etc. In another embodiment, encasement 34 may be an RF shield fabricated from metal or metalized plastic. In an alternative embodiment encasement 34 is woven to resemble a screen-like material or a net-like material. Encasement 34 may be any material suitable for encasing battery 30 including but not limited to fabrics, plastics, foams, metals, papers, cardboards, woods, glass, or fiberglass.

Fig. 6 is a circuit diagram of an example of one embodiment of the invention where the electronics is mounted on the tiles. For example, this circuit 60 could be used for transmitting

telemetry or for multilateration. In one embodiment, the control module circuitry 40 may be on one or more tiles. Control module 40 in Fig. 6 is interconnected to microwave circuitry 44. If microwave circuitry 44 resides on a different tile than control module 40, interconnect 42 between them may be flexible. Control module 40 is also interconnected to battery regulator 50 through interconnect 52. Interconnect 52 may be flexible.

In one embodiment, Antenna 48 is a directional antenna. The antenna 48 is designed to radiate electromagnetic radiation and direct it away from the user. This is particularly advantageous in any body mounted application where it is desirable to minimize exposure to electromagnetic radiation. In another embodiment, antenna 48 is flexible. In yet another embodiment, antenna 48 is a flat antenna. Flat antennas are advantageous because they do not protrude and cannot injure anyone. In still another embodiment, antenna 48 is fabricated by a printed-circuit board electrochemical process. As shown in Fig. 6 antenna 48 is connected to microwave circuitry 44 by interconnect 46. Interconnect 46 may be flexible.

Battery 54 may be disposable, reusable, or rechargeable. In one embodiment it is rechargeable by an inductive coupling as shown in Fig. 8. In another embodiment battery 54 is rechargeable through the use of a plug-type charging jack (not shown). In another embodiment battery 54 is replaced by a direct current source (not shown). In still another embodiment battery 54 is replaced by an alternating source (not shown). In a further embodiment battery 54 is replaced by a capacitor (not shown). In alternate embodiments multiple batteries 54 or current sources may be used (not shown). It should be appreciated that other wireless recharging systems may be used to recharge battery 54, as well as the inductive charging system shown in Fig. 8.

Control module 40 is interconnected to accelerometers 58 though interconnect 56. Note that interconnect 56 may be a flexible interconnect. Accelerometers 58 are an example of one application of the invention. Accelerometers 58 are sensors that feed data through interconnect 56 to control module 40 and ultimately through antenna 48 to a remote receiver which collects the data.

Accelerometers 58, in one embodiment, could be replaced or supplemented with other sensors (not shown). It should be appreciated that any sensor could be used in the system to monitor any required function. It has been contemplated that the system could monitor one or more of the following: temperature, blood pressure, pulse rate, blood sugar level, electrical activity in the brain, electrical activity in the heart, breath rate, breath force, distance traveled, sweat output, fat content, calories burned, urinary volume output, urinary flow rate, and bowel volume output, for example. In fact, a transceiver of the present invention could be used to monitor any biophysical data. The system in another embodiment could measure conditions external to the user such as temperature of the surrounding environment, humidity, rain, wind speed and direction, for example. In another embodiment, a sensor is in communication with a user's head and can sense signals from or transmit signals into the head.

Fig. 7 illustrates an embodiment of a helmet 74 of the present invention. In this embodiment, ventilation holes 70 can be utilized by charging probe 72 without modifying the protective or cooling properties of the helmet 74. The charging probe 72 in one embodiment is an inductive battery charging probe. In order to charge the internal battery, a user could merely position the probe correctly and inductive charging would commence. In another embodiment, charging probe 72 is merely a charging plug which attaches to a charging jack embedded in the helmet (not shown). In order to charge the battery in this embodiment, the user would merely

insert the charging plug into the charging jack (not shown).

Fig. 8 is a cross-sectional view of an embodiment of an inductive battery charging system of the present invention. The inductive charging system 90 includes an inductive charging probe 72 in electromagnetic communication with tiles 2 and 2'. Inductive charging probe 72 contains a coil that can be supplied with a charging current. The battery charging electronics can be contained within tiles 2 and 2'. Those electronics contain another coil which is in electrical communication with the battery charging circuit. As inductive charging probe 72 is positioned in close proximity to the battery charging electronics, a charging current from the first coil is induced into the second coil thereby activating the battery charging circuit and hence recharging the battery. The area(s) of inductive coupling 84 are shown in Fig. 8. In this embodiment of the invention, outer helmet shell 80 and inner helmet padding 82 remain unmodified thus providing the same comfort, fit, and protection specified by the manufacturer.

Having described and shown the preferred embodiments of the invention, it will now become apparent to one of skill in the art that other embodiments incorporating the concepts may be used and that many variations are possible which will still be within the scope and spirit of the claimed invention. It is felt, therefore, that these embodiments should not be limited to disclosed embodiments but rather should be limited only by the spirit and scope of the following claims.

Claims

We claim:

1. A transceiver for use with an apparel, the transceiver comprising:

a) a power supply;

b) a plurality of flexibly interconnected electrical components comprising a transmitter and receiver that are electrically coupled to the power supply, wherein the interconnected electrical components are substantially deformable so as to conform to a shape of the apparel; and

c) an antenna electrically coupled to the transmitter and receiver.

2. The transceiver of claim 1 wherein the antenna comprises a directional antenna that radiates electromagnetic radiation away from a user of the apparel.

3. The transceiver of claim 1 wherein at least one of the power supply, electrical components, and antenna is conformable to or shaped to mount on a user's body.

4. The transceiver of claim 1 wherein the shape of at least one of the power supply, electrical components, and antenna corresponds to the shape of a mounting surface of the apparel. The transceiver of claim 1 wherein the transceiver is electrically coupled to a sensor.

5. The transceiver of claim 1 wherein the transceiver is electrically coupled to a source comprising data, video, or audio.

6. The transceiver of claim 1 wherein the transceiver is substantially encapsulated in an environmentally protective material.

7. The transceiver of claim 7 wherein the protective material comprises plastic, fabric, metal, or cellulose.

8. The transceiver of claim 1 wherein the transceiver is disposed between a protective member and an outer surface of the apparel.

9. The transceiver of claim 1 wherein the transceiver is substantially disposed on the body of a user The transceiver of claim 1 wherein the power supply is a battery.

10. The transceiver of claim 11 wherein the battery is rechargeable.

11. The transceiver of claim 11 wherein the battery is rechargeable through a wireless recharging system.

12. An apparel comprising:

a) a transceiver comprising:

i) a power supply;

ii) a plurality of flexibly interconnected electrical components comprising a transmitter and receiver that are electrically coupled to the power supply, wherein the interconnected electrical components are substantially deformable to conform to a shape of the apparel; and

iii) an antenna electrically connected with at least one of the electrical components; and

b) support member for attaching the transceiver to the apparel.

13. The apparel of claim 14 wherein the antenna comprises a directional antenna that radiates electromagnetic energy away from a user.

14. The apparel of claim 14 wherein the transceiver is substantially encapsulated in an environmentally protective material.

15. The apparel of claim 14 wherein the transceiver is electrically coupled to a sensor.

16. The apparel of claim 14 wherein the transceiver is electrically coupled to a source comprising data, video, or audio.

17. The apparel of claim 14 wherein the apparel comprises a helmet.

18. The apparel of claim 14 wherein at least one of the power supply, electrical components, and antenna is conformable to or shaped to mount on a user's body.

19. The transceiver of claim 14 wherein the shape of at least one of the power supply, electrical components, and antenna corresponds to the shape of a mounting surface of the apparel.

20. The apparel of claim 14 wherein the power supply is rechargeable.

21. The transceiver of claim 14 wherein the power supply is rechargeable through a wireless recharging system.

22. A helmet comprising:

a) a helmet;

b) a transceiver attached to the helmet, the transceiver comprising:

i) a power supply;

ii) a plurality of flexibly interconnected electrical components comprising a transmitter and receiver that are electrically coupled to the power supply, wherein the interconnected electrical components are substantially deformable to conform to a shape of the helmet; and

iii) a directional antenna electrically connected to the transmitter and receiver that directs electromagnetic radiation away from a user of the helmet; and

c) support member for attaching the transceiver to the helmet.

23. The helmet of claim 24 wherein the transceiver is disposed substantially within the user's helmet.

24. The helmet of claim 24 wherein the transceiver is substantially encapsulated in an environmentally protective material.

25. The helmet of claim 24 wherein the transceiver is disposed between a protective member and an outer surface of the helmet.

26. The helmet of claim 24 wherein at least one of the power supply, electrical components, and antenna is conformable to or shaped to mount on a user's head.

27. The transceiver of claim 24 wherein the shape of at least one of the power supply, electrical components, and antenna corresponds to the shape of a mounting surface of the apparel.

28. The helmet of claim 24 wherein the transceiver is electrically coupled to a sensor.

29. The helmet of claim 30 wherein the sensor is in communication with at least a portion of a user's head.

30. The transceiver of claim 24 wherein the transceiver is electrically coupled to a source comprising data, video, or audio.

31. The helmet of claim 24 wherein the power supply comprises a battery.

32. The helmet of claim 24 wherein the power supply is rechargeable.

33. The transceiver of claim 24 wherein the power supply is rechargeable through a wireless recharging system.

34. A method of recharging a battery in a helmet, the method comprising the steps of:

a) supplying a charging current into a first coil of a recharging system; and

b) positioning the helmet comprising a second coil in electromagnetic communication with the first coil;

wherein a charging current is induced from the first coil to the second coil, thereby charging the battery in the helmet.

35. An electronic device for use with an apparel, the electronic device comprising:

a) a flexible power supply; and

b) a plurality of flexibly interconnected electrical components that are electrically coupled to the flexible power supply, wherein the interconnected electrical

components are substantially deformable so as to conform to a shape of the apparel.

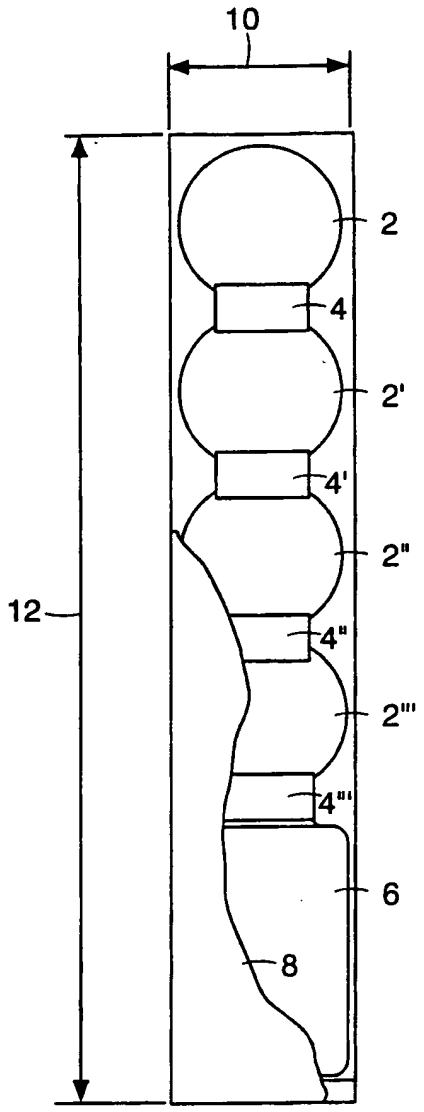


FIG. 1a

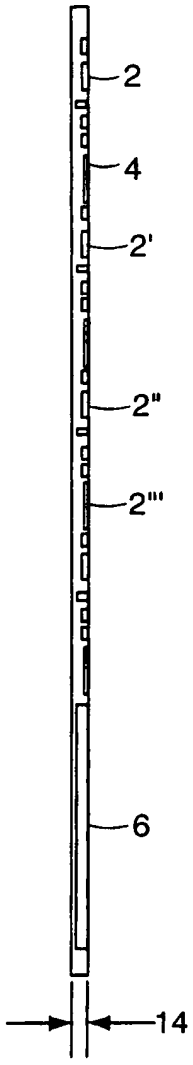


FIG. 1b

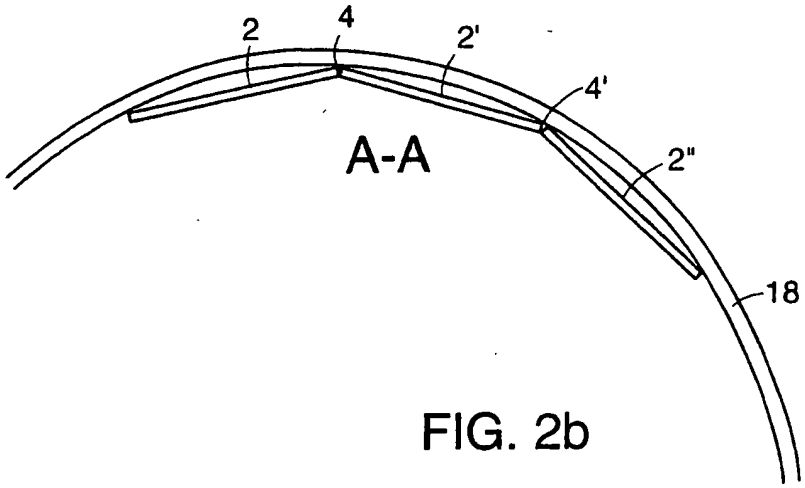


FIG. 2b

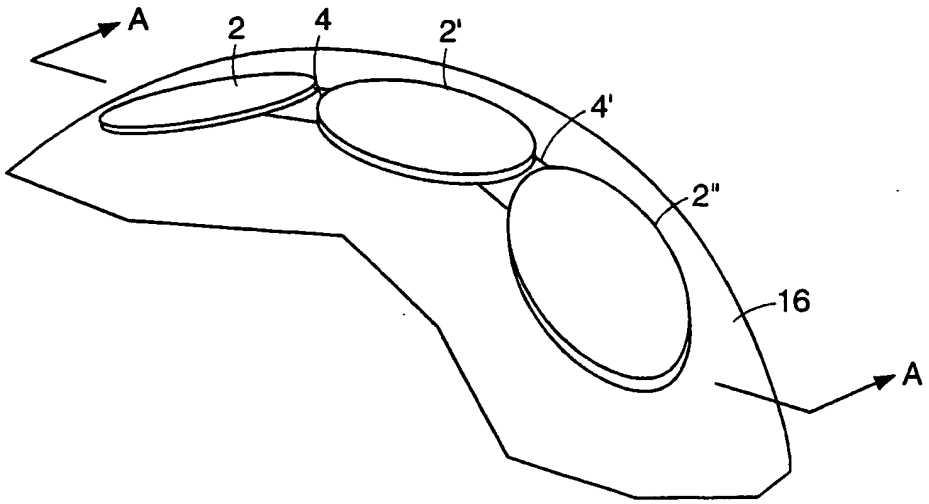


FIG. 2a

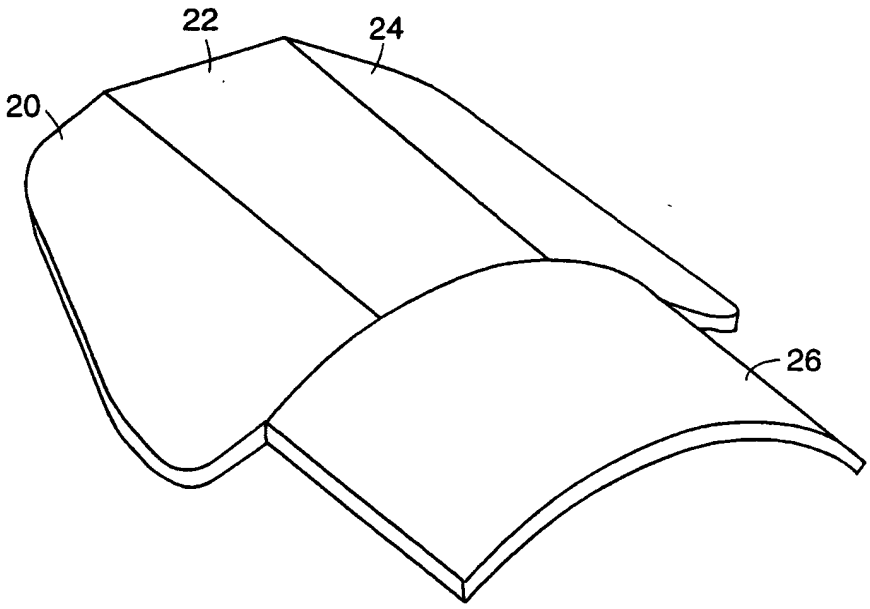


FIG. 3

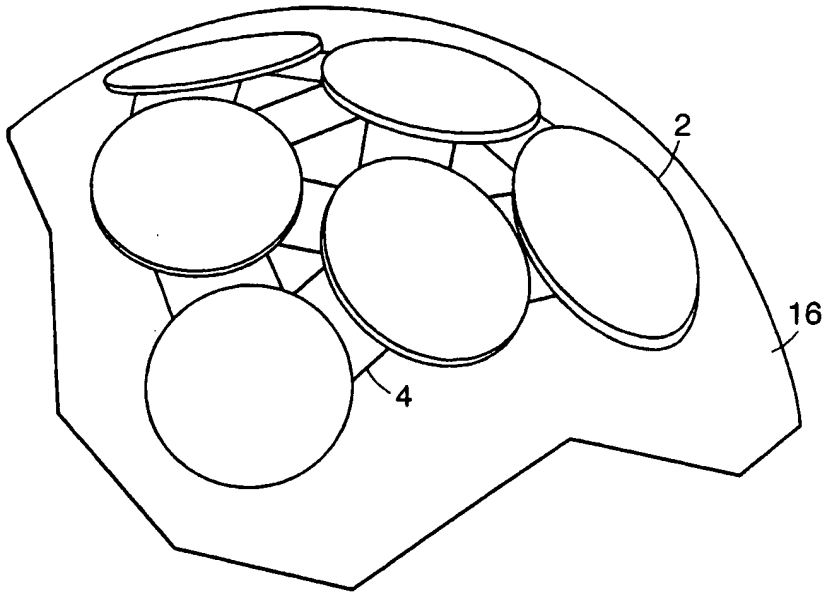


FIG. 4

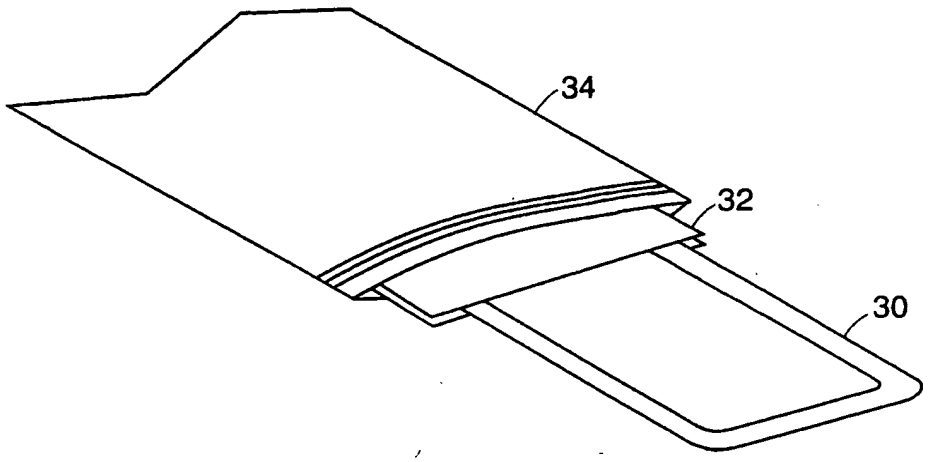
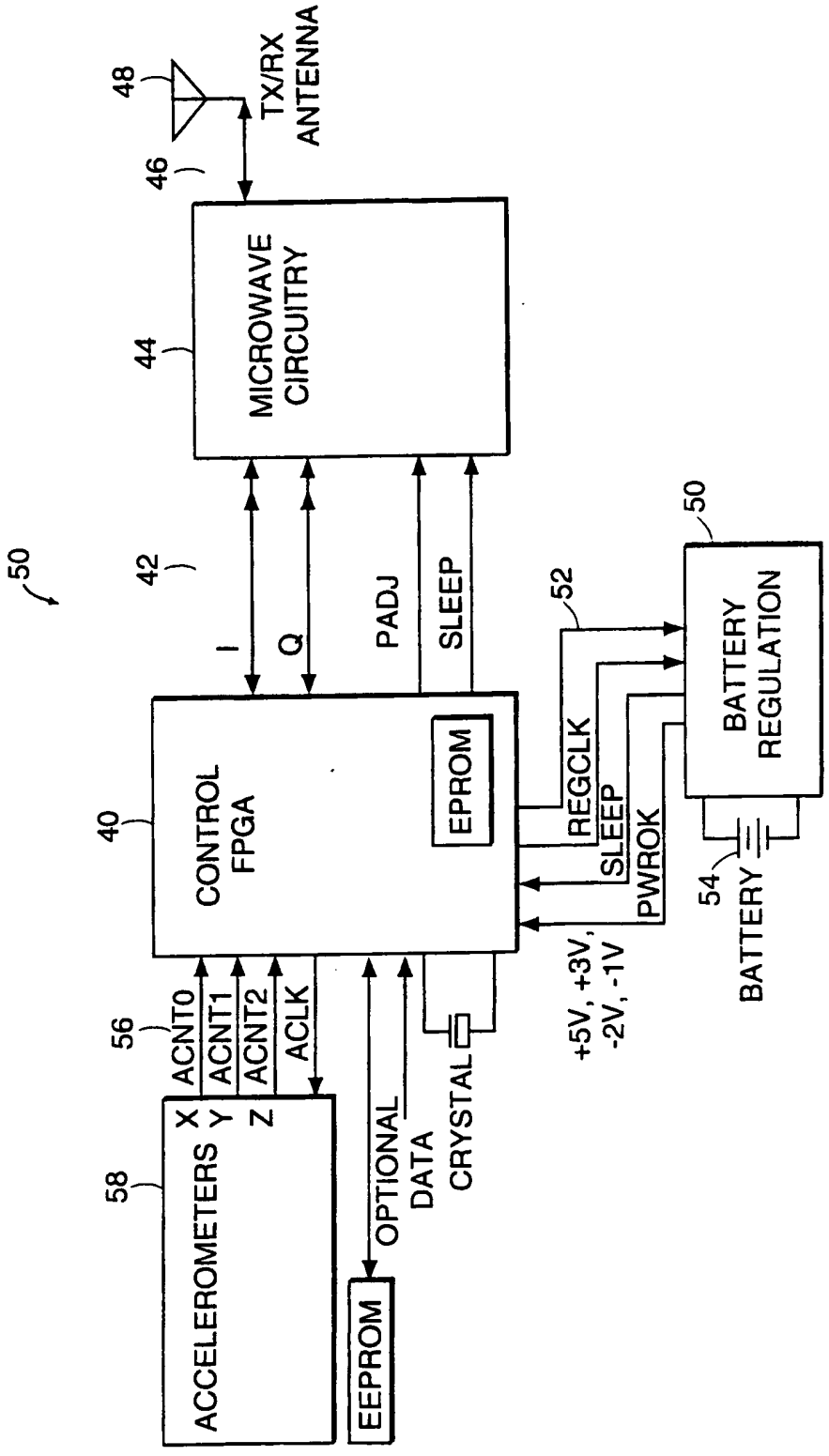


FIG. 5


48
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46
44
MICROWAVE CIRCUITRY
50
42
I
Q
PADJ
SLEEP
52
50
BATTERY REGULATION
40
CONTROL FPGA
EPROM
REGCLK
SLEEP
PWROK
54
BATTERY
+5V, +3V, -2V, -1V
56
ACNT0
ACNT1
ACNT2
ACLK
CRYSTAL
58
ACCELEROMETERS
X
Y
Z
OPTIONAL DATA
EEPROM

FIG. 6

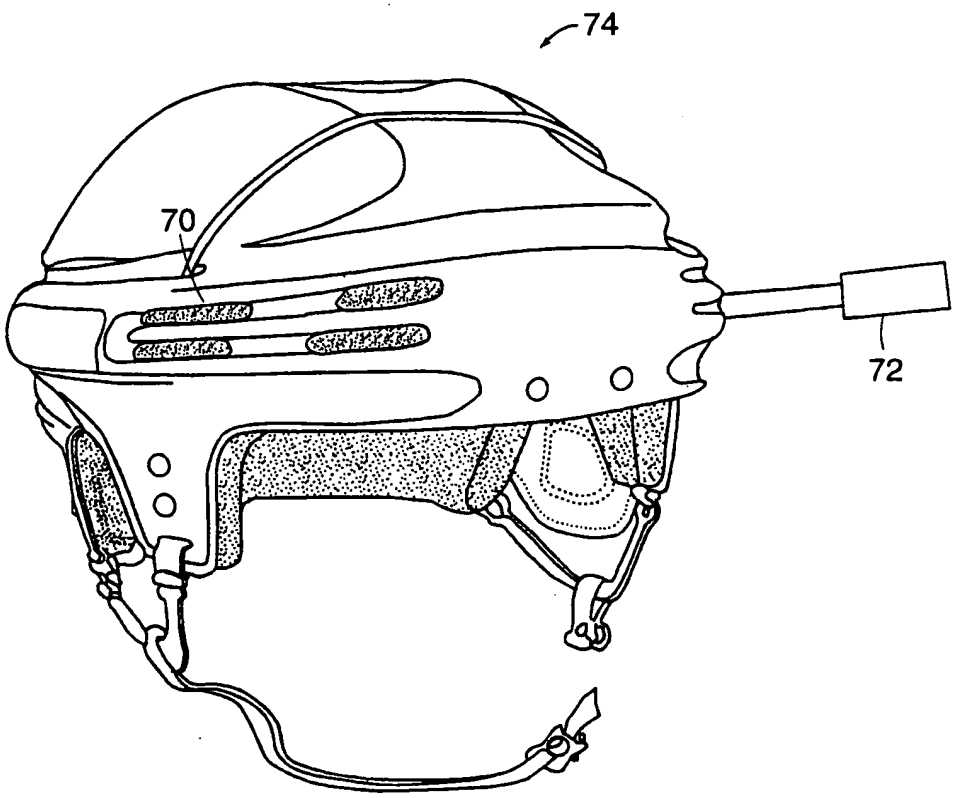

FIG. 7

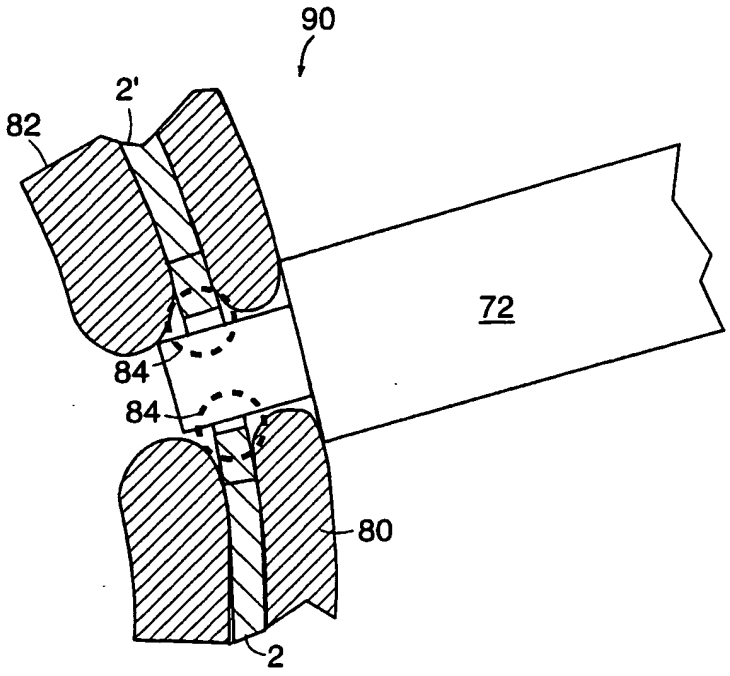

FIG. 8

INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 99/21659

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 5 521 794 A (HARGRAVE PHILLIP C ET AL) 28 May 1996 (1996-05-28) column 1, line 58 -column 3, line 6; figures 1,2,4	1,3, 6-12,37 2,4,5, 13-36

X Y A	US 3 983 483 A (PANDO DONALD J) 28 September 1976 (1976-09-28) column 2, line 53 -column 5, line 48; figure 1	1,3,4, 6-12,14, 16,18, 20-23,37 2,15, 24-26, 28,29, 32-34 5,13,17, 19,24-36

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
17 December 1999	12/01/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Andersen, J.G.

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INTERNATIONAL SEARCH REPORT

Inter. ...nal Application No
PCT/US 99/21659

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropnate, of the relevant passages	Relevant to claim No.
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A	abstract	1-23,27, 30,31, 35-37
P,Y	US 5 884 198 A (YOON JOHN ET AL) 16 March 1999 (1999-03-16) abstract; figures 2,3	2,15
A	US 5 757 929 A (WANG WEIJIA ET AL) 26 May 1998 (1998-05-26)	
A	US 5 410 746 A (GELBER HUGH T) 25 April 1995 (1995-04-25)	

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INTERNATIONAL SEARCH REPORT

...formation on patent family members

Inter nal Application No
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